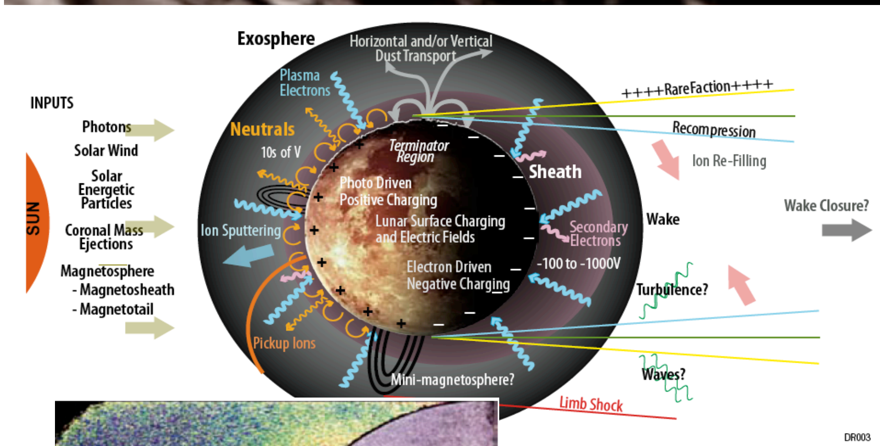
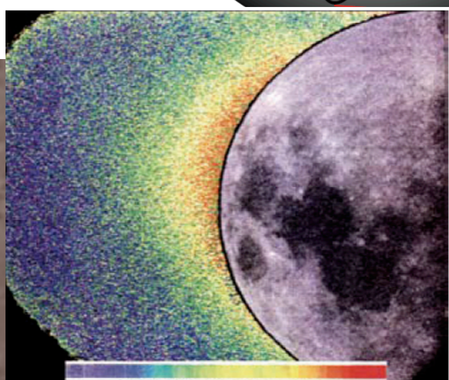
Dynamic Response of the Environment At the Moon





The dynamic moon: Solar stimulated neutral emission and plasma interactions

Observations of lunar sodium atmosphere

Astronaut in Shackleton

- Theory, modeling, data validation effort of the solar-lunar environment connection
- “How does the highly-variable solar energy and matter incident at the surface interface affect the dynamics of lunar volatiles, ionosphere, plasma, and dust?”
- Emphasize the dynamics – solar storms and impacts at the Moon
- Modeling center that maintains, advances and integrates state-of-the-art neutral, plasma, and surface interaction models
- Applications to exploration

DREAM

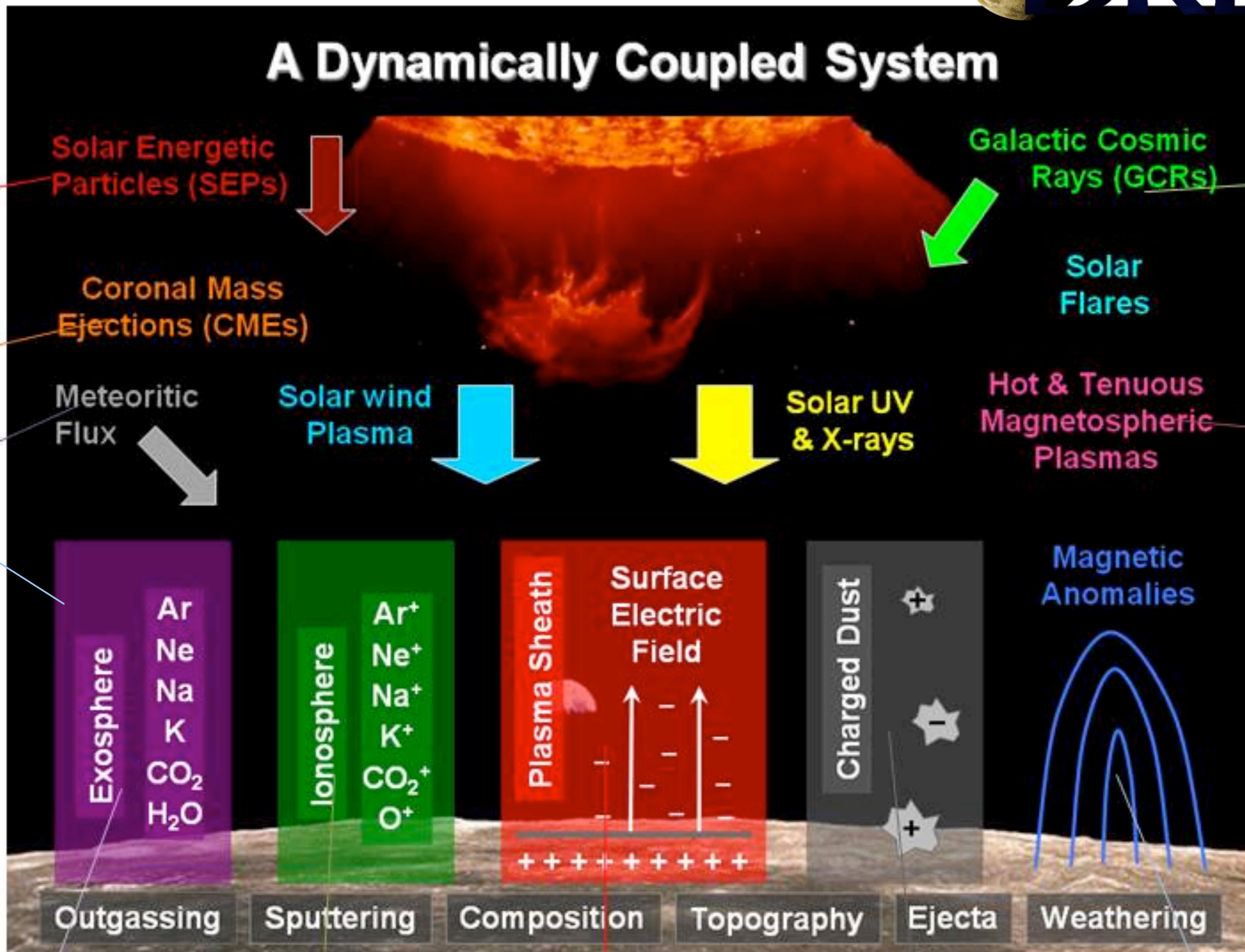
Lin (UCB)

Bale (UCB)

Colaprete (ARC)

Spence (BU)

Patterson (HU)



GSFC
UCB
UMBC
JHU/APL
ARC
UColo
BU
NMst
HU
SETI
SSAi

Crider (APL)
Killen (UMD)
Hodges (UTD)
Vondrak (GSFC)

Sarantos (UMD)
Hartle (GSFC)
Elphic (ARC)
Collier (GSFC)

Farrell (GSFC)
Delory (UCB)
Jackson (GSFC)

Stubbs (UMBC)
Marshall (SETI)
Glenar (NMSU)

Krauss-Varben (UCB)
Hesse (GSFC)
Halekas (UCB)
Keller (GSFC)

"How does the highly-variable solar energy and matter incident at the surface interface affect the dynamics of lunar volatiles, ionosphere, plasma, and dust?"

DREAM has four supporting themes that address this overarching question:

1. Advance understanding of the surface release and loss of the **neutral gas exosphere** over small to large spatial scales and a broad range of driver intensities.

2. Advance understanding of the enveloping **plasma interaction region** over small to large spatial scales and over a broad range of driver intensities.

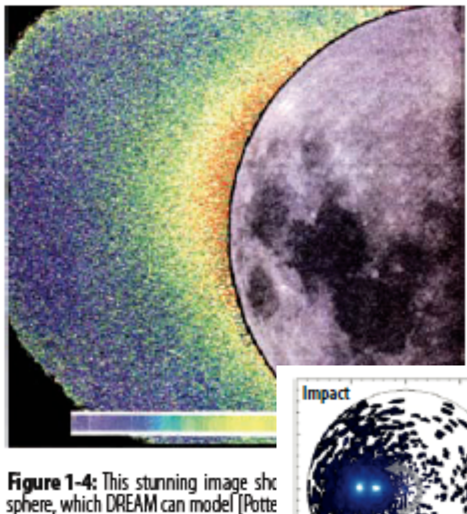
3. Identify **common links** between the neutral and plasma systems and test these linkages by modeling **extreme environmental events.**

4. **Apply** this new-found environmental knowledge to guide decision-making for future missions, assess the Moon as an observational platform, and aid in human exploration.

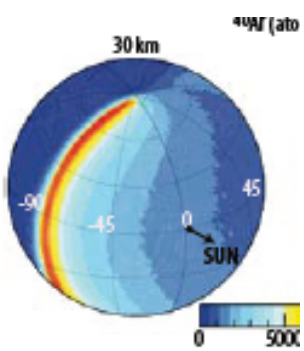
DREAMs first model

DREAM

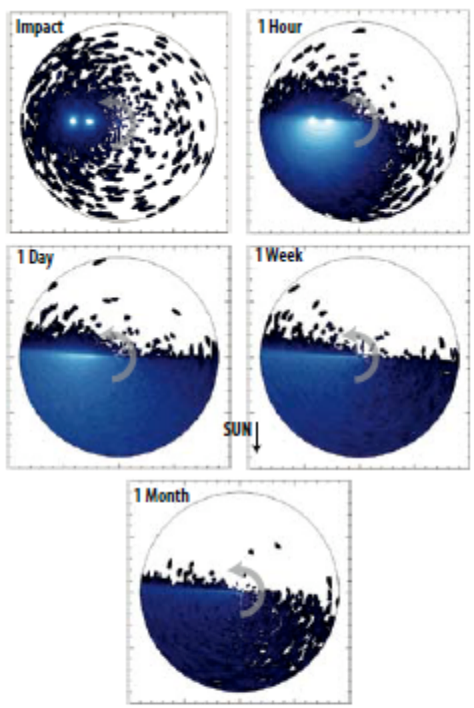
Approach to Objective 1- Exosphere



Na observations



Hodges' Ar-40



Crider's snowball

-A tenuous neutral gas surrounds the moon

-Exosphere: gas is collisionless

-Composition not fully known

-Why not more H and O based species

-Energetics not fully understood

-Water can be implanted or possibly created at surface and migrate to cold traps

To understand this DREAM will:

-Advance models of volitization of water, transport, and collection in traps

-Advance Monte Carlo exospheric models

-Model chemical sputtering

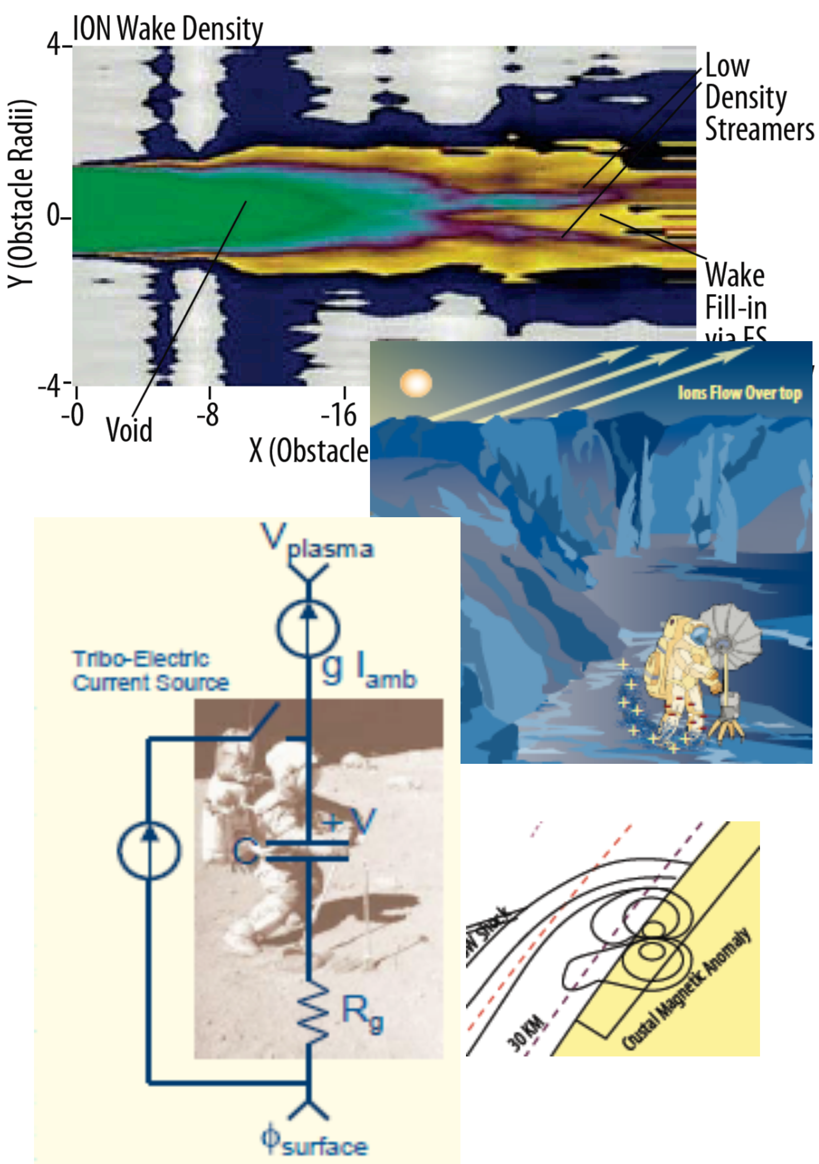
-Model sputtering of regolith with solar driver

-Improve exo-ionosphere models

-Advance impact models -> dissipation

- Validate (LACE, Kaguya), Prediction (LRO, LCROSS LADEE)

Approach to Objective 2 – Plasma Interactions



- -Moon is an obstacle in outflowing solar wind
- -Creates a trailing lunar wake affected by SW dynamics that we don't know
- -Mini-wakes may form along polar terrain that effect the local electrical environment
- -Magnetic anomalies form regional perturbations
- -Human systems are places in this electrical environment
- -Dust is part of this electrical environment

To understand this DREAM will:

- -Advance PIC and Hybrid sims to model wake, sheath, anomalies, and surface
- -Develop models and sim of polar mini-wake formation
- -Create surface cohesion model – apply to dust lifting
- -Advance models to tribo-charging human systems on the moon
- -Validate (LP, SIDE, Kaguya), Prediction (LRO, LCROSS, LADEE, Exploration)

Approach to Objective #3

DREAM

Cross-Integration and Extremes

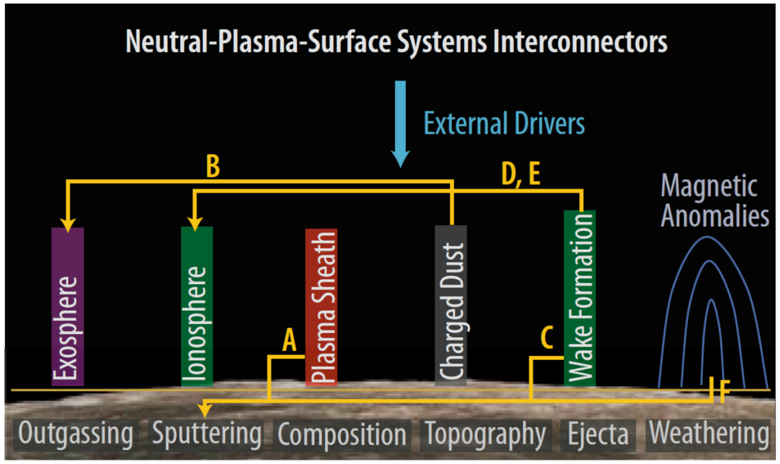


Figure 1-14: DREAM will examine new surface emission system interconnections, revealing previously unknown cross-connections.

The lunar atmosphere and plasma systems treated mostly as independent – their communities are separate entities

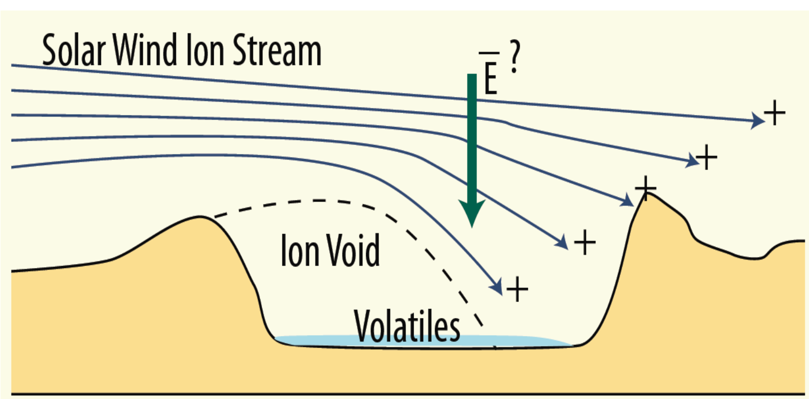
-New recognition that there are common ties

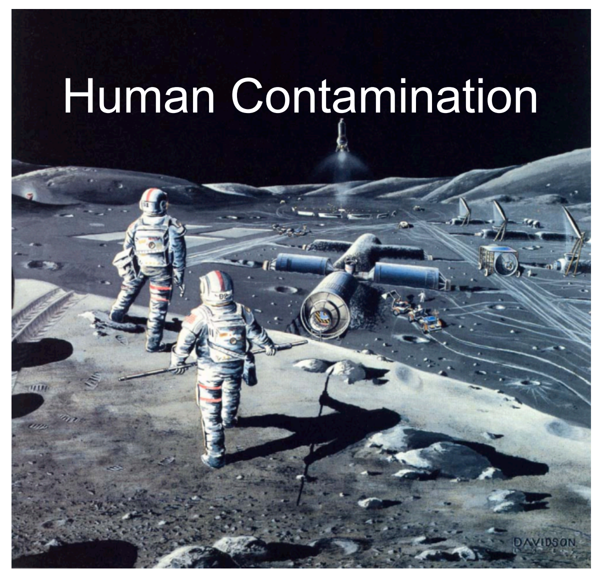
-DREAM emphasizes that integration

-Will hold a <u>set of summits </u>to merge exosphere models with plasma models/sims

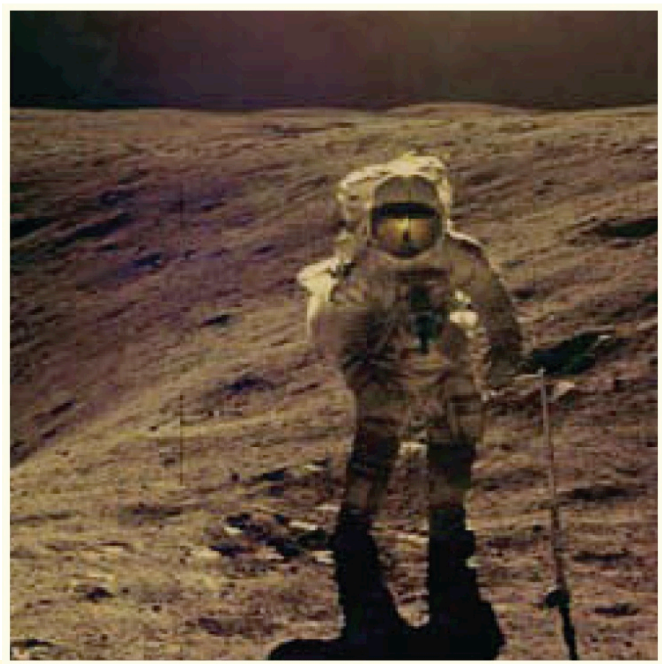
-first ‘Lunar Aeronomy’

Polar Shadowed Craters





Integration Focal Point:
Lunar Extreme Workshops (LEWs)



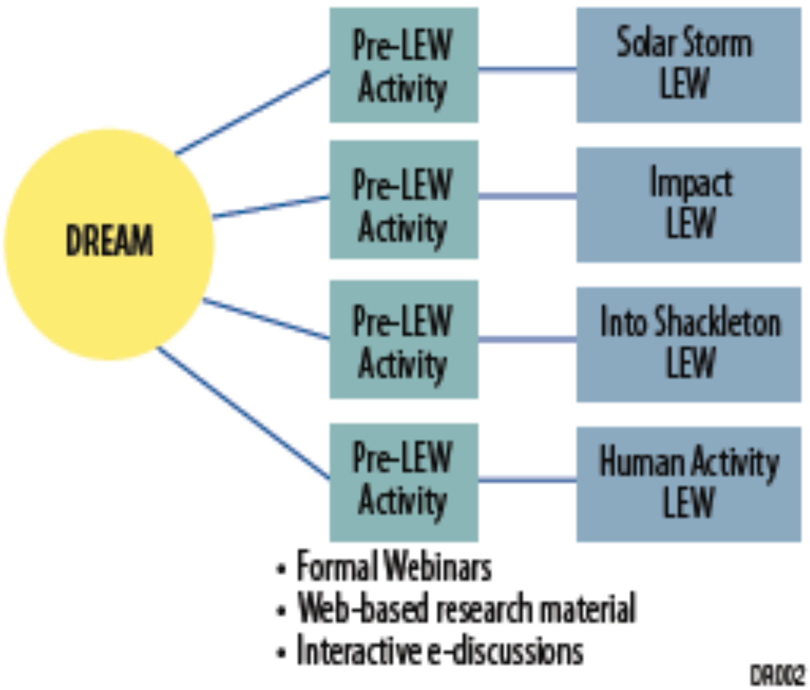
Will test **sets of models as a system** under environmental extremes in a coordinated workshop environment:

-**Solar Storms** – Mock storm on Moon that affects sputtering, exo-ions, surface charging, and Shackleton resources and charging

-**Impacts** – Mock impact to determine the evolution of gas and dust in surrounding environment. Consider small and moderate sized impacts and obtain dissipation process/rates

E/PO – Have students participate directly in activity and be part of the action. Integration of young scientists as well.

Supporting Other Institute Objectives



E/PO – strong connection w/ LEWs
-include high school student/teachers
-pre-LEW webinars and prep material
-tap into excitement of 'encounters'

-UCB hold weekly
student lunar seminars

-UCB, BU, UM – support grad stud (4)
-GSFC coop
-ARC & GSFC – NPP post-docs
(cost shared)
-HU & UCB – Post Doc each

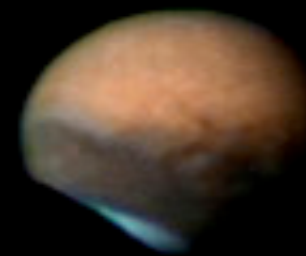
-Web interface/portal via existing CCMC space weather modeling center – get lunar weather

-Social media

- Videoconferencing & Adobe Connect

Conclusion

- DREAM LSI team is getting start (April 1 2009 start date)
- Products being created now
- Support the community – LCROSS, LRO, LADEE
- Dust and Atmosphere focus group



DREAM Models

CCMC MHD codes of solar wind/CMEs

Monte Carlo Exosphere (Crider/Killen)
Monte Carlo Regolith (Crider/Vondrak)
Ar-40 Monte Carlo Sims (Hodges)
Neutral/surface ejection (Sarantos/Killen)
Exo-ion pickup (Hartle)
Impact Model – LCROSS (Colaprete)
Impact Model – Snowball (Crider)

Hybrid/Kinetic plasma sims (Krauss-Varben)
Kinetic wake sim (Farrell)
Equivalent circuit model (Farrell/Jackson)
Surface charging model (Stubbs)
Dust Fountain model (Stubbs)
Mie scattering model (Glenar)

DREAM Validation Sets

Direct (public domain):
WIND (Lin/Bale)
GEOTAIL (Peterson)
SIDE ALSEP (Collier)
LP MAG/ER (Lin)
Apollo 15/16 subsat plasma

Indirect (access via co-i):
ARTEMUS (many)
Kaguya PACE (Saito, Elphic)
LRO (Vondrak, Keller, Stubbs, Spence)
LCROSS (Colaprete)
LADEE (Colaprete, Horanyi)
Constellation (Hyatt, Farrell, Dube)